Phase separations in colloidal solutions(Soft Matter as Structured Materials)

AUTHOR(S):

Matsuyama, Akihiko

CITATION:

Matsuyama, Akihiko. Phase separations in colloidal solutions(Soft Matter as Structured Materials). 物性研究 2005, 84(6): 865-866

ISSUE DATE:

2005-09-20

URL:

http://hdl.handle.net/2433/110329

Phase separations in colloidal solutions

Dept. of Bioscience and Bioinformatics, Kyusyu Institute of Technology
Akihiko Matsuyama[1]

A mean field model is introduced to describe phase separations in colloidal solutions. Combining Flory-Huggins theory modified for colloidal solutions with a translational order parameter of a face-centered-cubic structure for colloidal crystals, we calculate the phase diagrams. We find a metastable liquid-liquid, liquid-solid, and solid-solid phase separation, which can be defined by the translational order parameter and concentration. The theory presented describes the features of the phase diagrams observed in a wide variety of colloidal systems.

コロイド溶液における相分離現象を記述するための平均場理論を紹介する。Flory-Hugggins理論をコロイド系に修正し、コロイド粒子の体心立方構造などの結晶の並進秩序パラメーターを考慮することで自由エネルギーを構築した。理論は実験的に観測されている相図を再現することが出来た。コロイドの結晶化と相分離の競合により様々な相分離が可能である。

1 Summary

The phase behaviors of colloidal solutions have been studied because of not only their great theoretical interest but also for many industrial applications. The most commonly observed phase transition is a liquid-solid phase separations (sodification), where the concentrated colloidal phase shows a crystalline structure. The other is a liquid-liquid phase separation (coacervation), where a colloid-rich and a colloid-poor phase can coexist[1].

In colloidal solutions, it is important to consider co-occurrences between phase separation and crystalline ordering, such as a face-centered cubic (fcc), body-centered cubic (bcc), and simple-cubic (sc) structure. In colloidal crystals, the decrease in entropy associated with a nonuniform mean density is compensated by a greater local volume that each particle can independently explore. These inhomogeneous mixtures can be described by one conserved order parameter (concentration) and one nonconserved order parameter (translational order parameter), such as polymer-liquid crystal mixtures where the concentration and orientational order parameter of liquid crystals describe the phase behaviors[2].

In this paper, we present a simple model to describe phase separations in colloidal solutions by taking into account a translational order parameter of a fcc structure for crystallization. The

[1]E-mail: matuyama@bio.kyutech.ac.jp

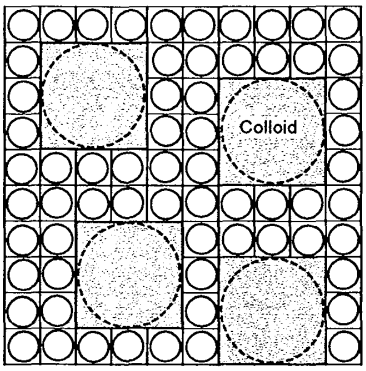

Figure 1: Lattice model for Colloidal solutions. Gray sites are occupied by colloids and white sites are occupied by solvent molecules.

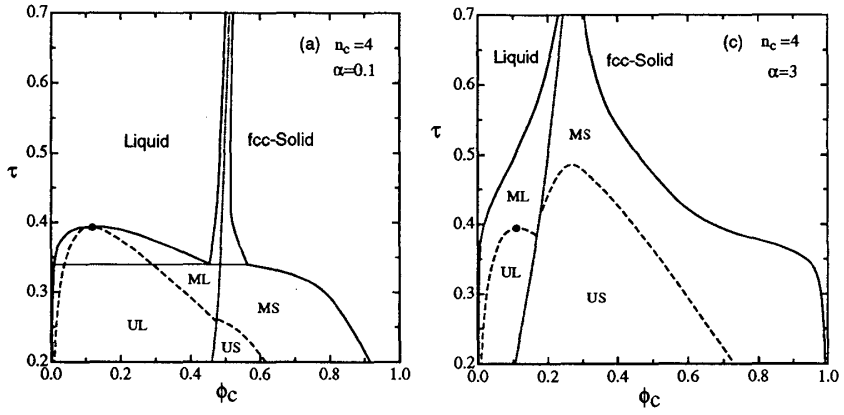

Figure 2: Phase diagram for $n_c^3 = 64$. The attractive interaction parameter α is changed: (a) $\alpha = 0.1$; (c) $\alpha = 3$.

free energy of colloidal solutions is modeled by an extension of Flory-Huggins theory for polymer solutions. The translational order parameter of colloids in the solid phase is calculated as a function of temperature and concentration. Depending on the size of a colloid and the strength of an attractive interaction between colloids, the theory presented successfully describes the features of the phase diagrams observed in a wide variety of colloidal systems. We also compare our theory with the experimental phase diagrams of lens protein solutions.

References

[1] *Soft and Fragile Matter*, edited by M. E. Cates and M. R. Evans, (Institute of Physics Publishing, Bristol, 2000) and see references cited therein.

[2] A. Matsuyama and T. Kato, J. Chem. Phys. **108**, 2067 (1998).